UNIVERSITY TRANSPORTATION CENTER

RESEARCH BRIEF

PROJECT TITLE: Analytical Tools for Resilience of Lifeline Highway Bridges to Tsunami Events

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INSTITUTION: SINGLE-INSTITUTION PROJECT
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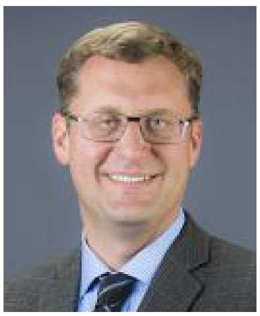
SPONSORS: THE PACIFIC NORTHWEST TRANSPORTATION CONSORTIUM, ODOT



Background

Highway bridges serve as critical lifelines after natural disasters such as earthquakes and tsunamis. While earthquakes over the last quarter century, e.g., Loma Prieta and Northridge, have led to rapid evolution of design codes for buildings and bridges, the less frequent but potentially more catastrophic threat of a tsunami has come to the forefront of resilience-based design for coastal infrastructure. The 2004 Indian Ocean tsunami exposed the vulnerability of coastal infrastructure and lifelines in many southeast Asian countries while the 2011 tsunami that struck the east coast of Japan reinforced the fact that countries with modern design standards, based primarily on seismic hazards that exceed those in the United States, are at significant risk for damage and total loss from tsunami inundation.

Geologic conditions similar to those found off the east coast of Japan are also present off the west coast of the United States. The Cascadia subduction zone (CSZ) poses a direct threat for a major tsunami that could impact the coastlines of Oregon, Washington, and northern California. The CSZ last triggered an earthquake and subsequent tsunami about 400 years ago and has a high probability of unleashing a similar event in the next 100 years. The ability of bridges along the Oregon and Washington coasts to resist the demands posed by forecast tsunami events is in doubt and research is underway to address this issue.

Research Project

This work aims to develop simplified engineering tools for tsunami load effects on bridges. This will consist of analyzing data from wave flume experiments on bridges and developing simple analytical models of bridges subjected to tsunami loads. Single degree-of-freedom (SDF) models have guided the design of structures to resist seismic loads from earthquake ground motion since the 1960s.

This project will extend the response spectra concept to SDF models of bridge superstructures subjected to a time history of hydrodynamic forces. The natural period dependence will be based on bridge weight and the stiffness of connections between the superstructure and substructure. Linear-elastic systems will be investigated first followed by systems with nonlinearity owing to bearing failure and/or the presence of shear keys.

Previous wave flume experiments have examined a wide range of bridge deck configurations (open girder, closed soffitt), the presence of bridge rails, and venting strategies to release air trapped between girders. In addition, the effects of connection stiffness between the bridge deck and superstructure and of added mass have been examined and shown to affect the dynamic bridge response. Experimental observations of dynamic effects owing to mass and stiffness will be used as validation for the simplified analytical SDF models, thereby providing engineers with easy-to-use tools that can help guide the design and assessment of bridge to resist tsunami loading.